



US006539910B1

(12) **United States Patent**
Gaiser et al.

(10) **Patent No.:** **US 6,539,910 B1**
(45) **Date of Patent:** **Apr. 1, 2003**

(54) **CLOSED GALLERY PISTON HAVING CON
ROD LUBRICATION**

(75) Inventors: **Randall R. Gaiser**, Chelsea, MI (US);
Carmo Ribeiro, Ann Arbor, MI (US);
Eduardo H. Matsuo, Ann Arbor, MI
(US)

(73) Assignee: **Federal-Mogul World Wide, Inc.**,
Southfield, MI (US)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 0 days.

4,776,075 A	10/1988	Kawabata et al.
5,052,280 A	10/1991	Kopf et al.
5,144,923 A	9/1992	Leites et al.
5,413,074 A	5/1995	Horiuchi
5,483,869 A	1/1996	Bock et al.
5,778,533 A	7/1998	Kemnitz
5,794,582 A	8/1998	Horiuchi
5,913,960 A	6/1999	Fletcher-Jones
5,934,174 A	8/1999	Abraham, Sr. et al.
5,979,298 A	11/1999	Whitacre
6,003,479 A	12/1999	Evans
6,032,619 A	3/2000	Zhu et al.
6,152,016 A	11/2000	Bahr et al.
6,286,414 B1 *	9/2001	Kruse 92/186
6,327,962 B1 *	12/2001	Kruse 92/186

* cited by examiner

(21) Appl. No.: **09/957,704**

(22) Filed: **Sep. 19, 2001**

(51) **Int. Cl.**⁷ **F01B 31/08**

(52) **U.S. Cl.** **123/193.6**

(58) **Field of Search** 123/193.6, 41.35;
92/186, 238

Primary Examiner—Marguerite McMahon
(74) *Attorney, Agent, or Firm*—Reising, Ethington, Barnes,
Kisselle, Learman & McCulloch, P.C.

(57) **ABSTRACT**

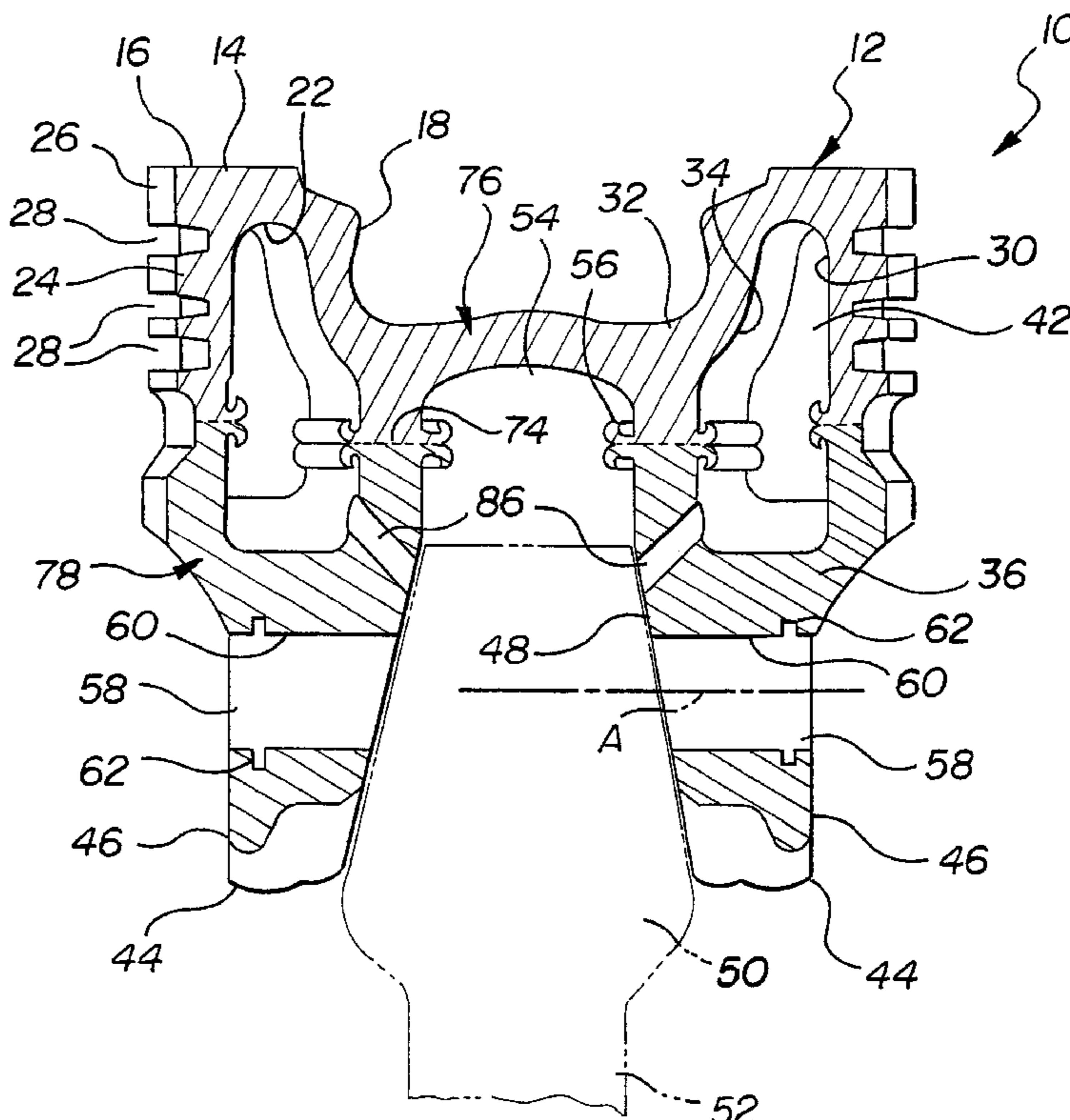
A piston for diesel engines includes a piston body having a closed oil gallery and a pair of pin bosses with axially aligned pin bores. The inner faces of the pin bosses are separated from one another by an intervening space between the pin bosses for receiving the upper end of a connecting rod, which has associated outer faces adjacent the inner faces of the pin bosses. Oil passages extend from the gallery and open to the inner faces of the pin bosses for providing direct lubrication to the inner faces.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,011,797 A	3/1977	Cornet
4,180,027 A	12/1979	Taylor
4,270,494 A *	6/1981	Garter et al. 123/193.6
4,331,107 A	5/1982	Bruni
4,581,983 A	4/1986	Moebus
4,662,319 A	5/1987	Ayoul

9 Claims, 3 Drawing Sheets



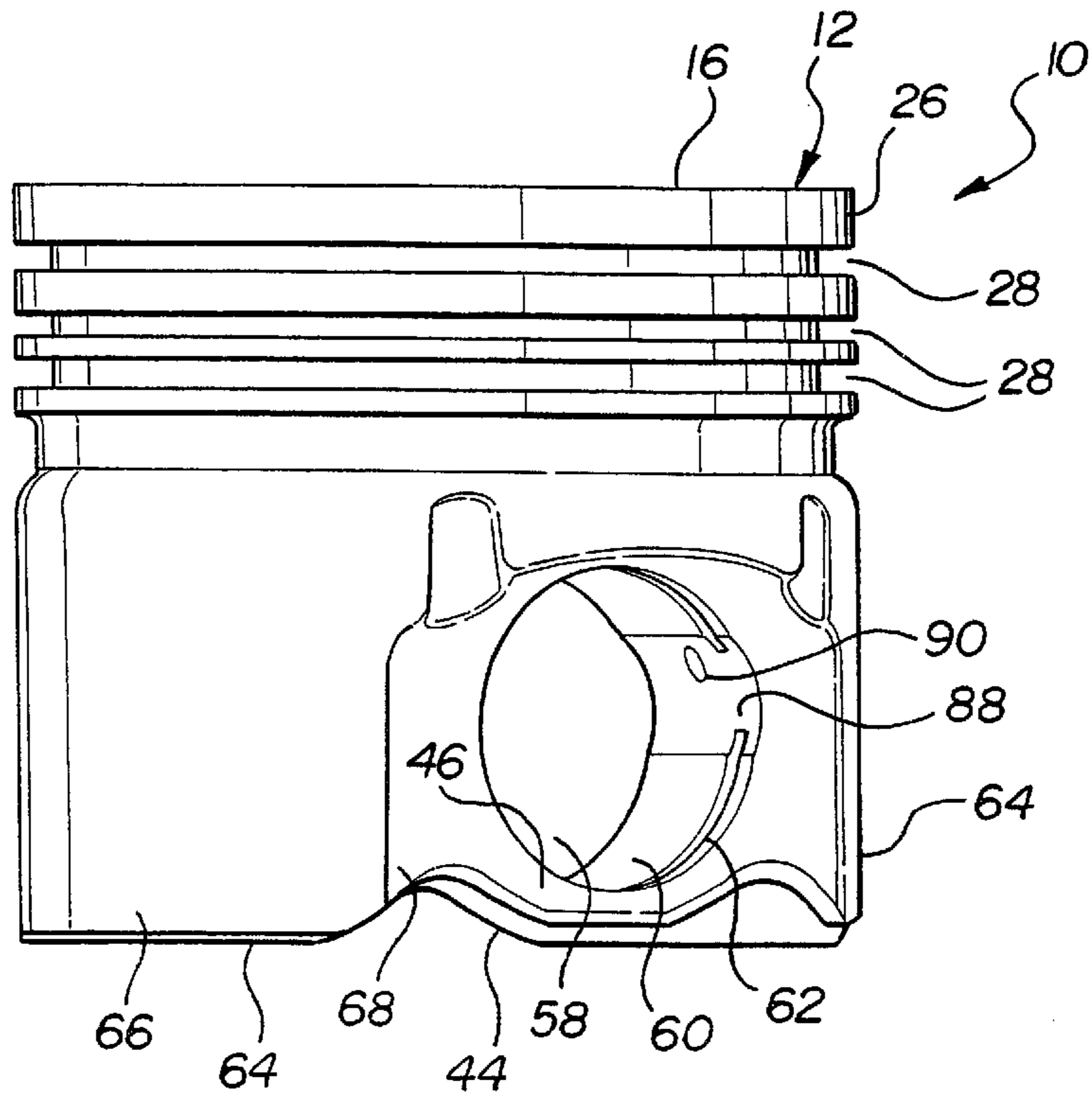


FIG-1

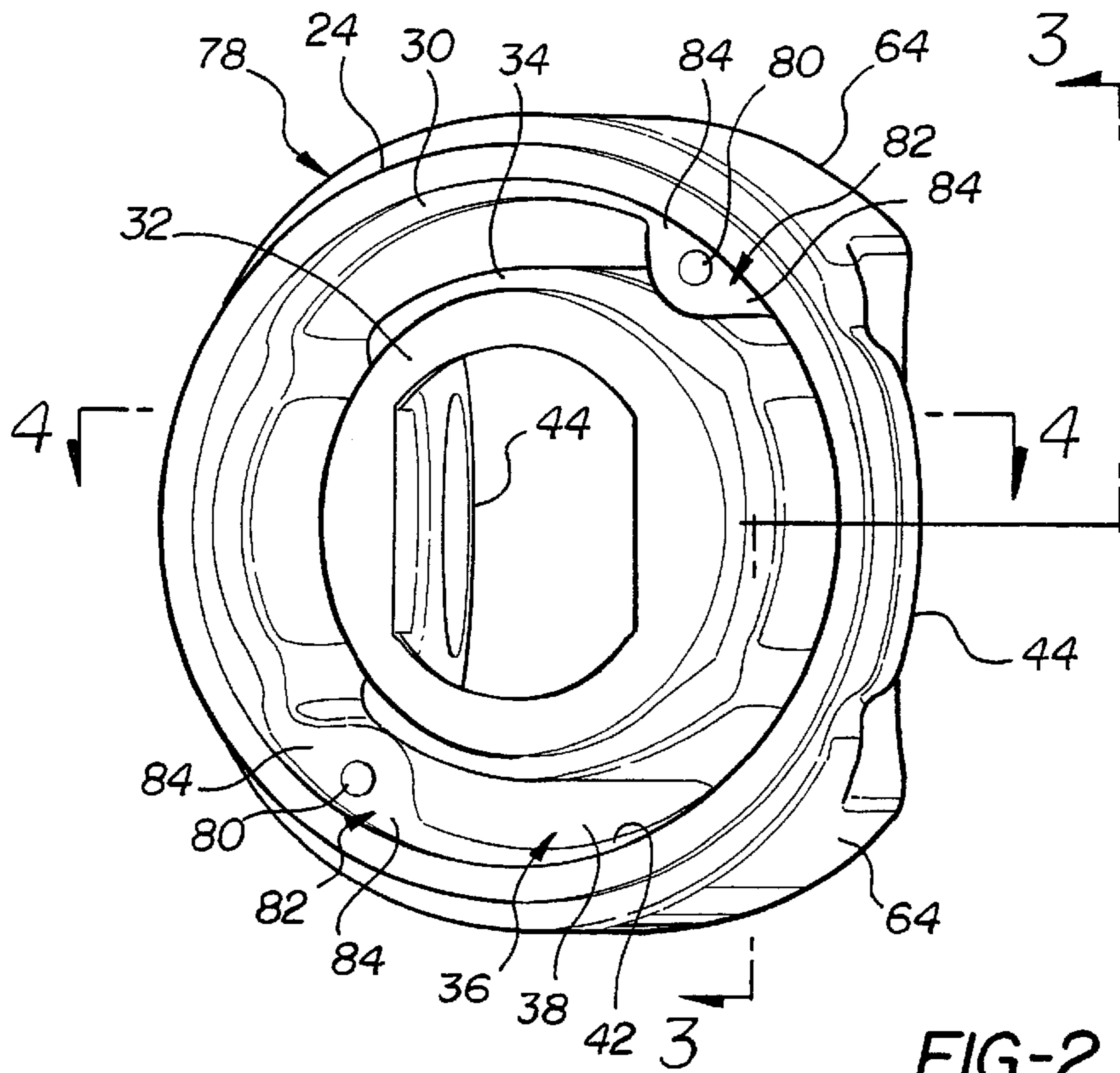
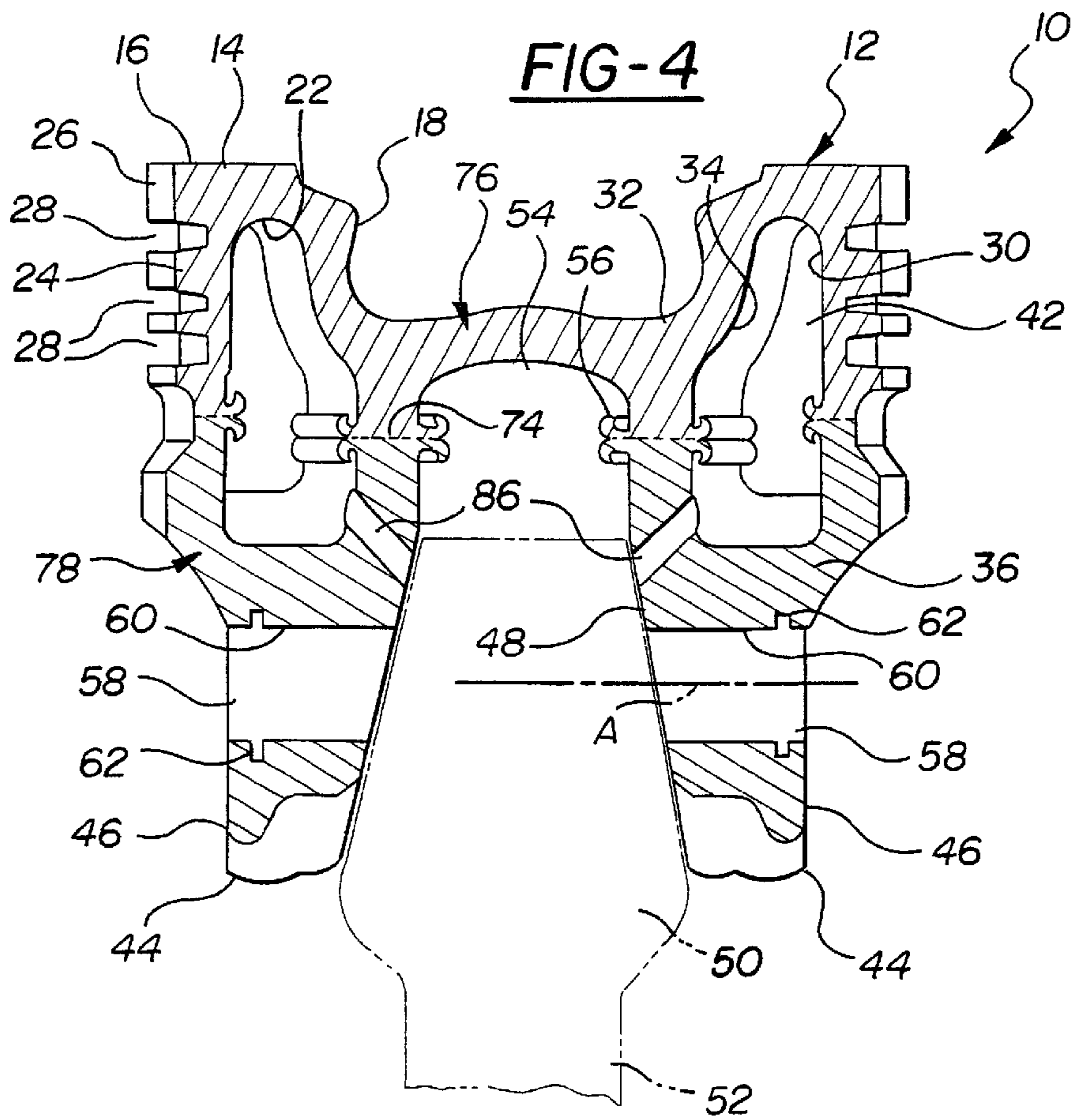
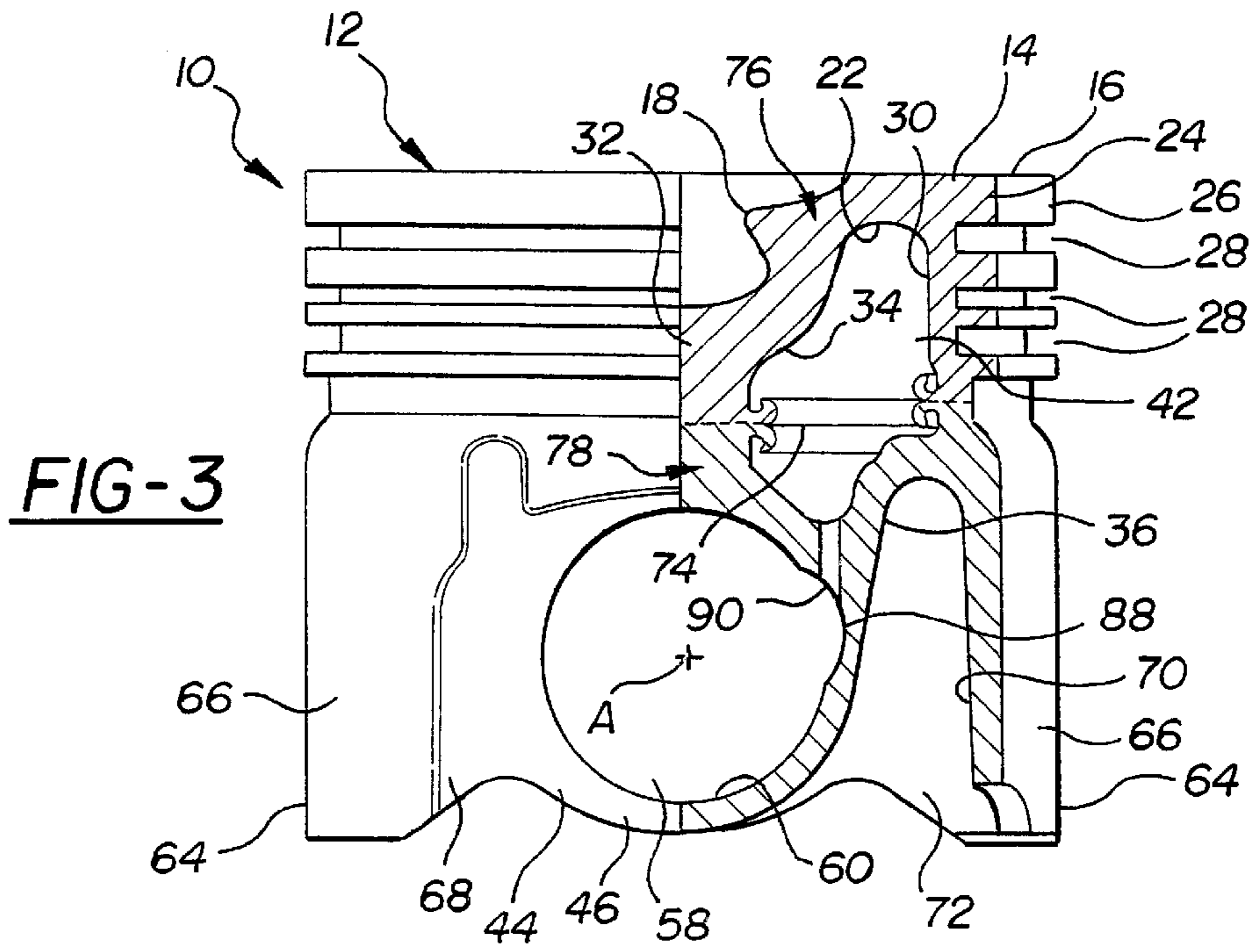


FIG-2



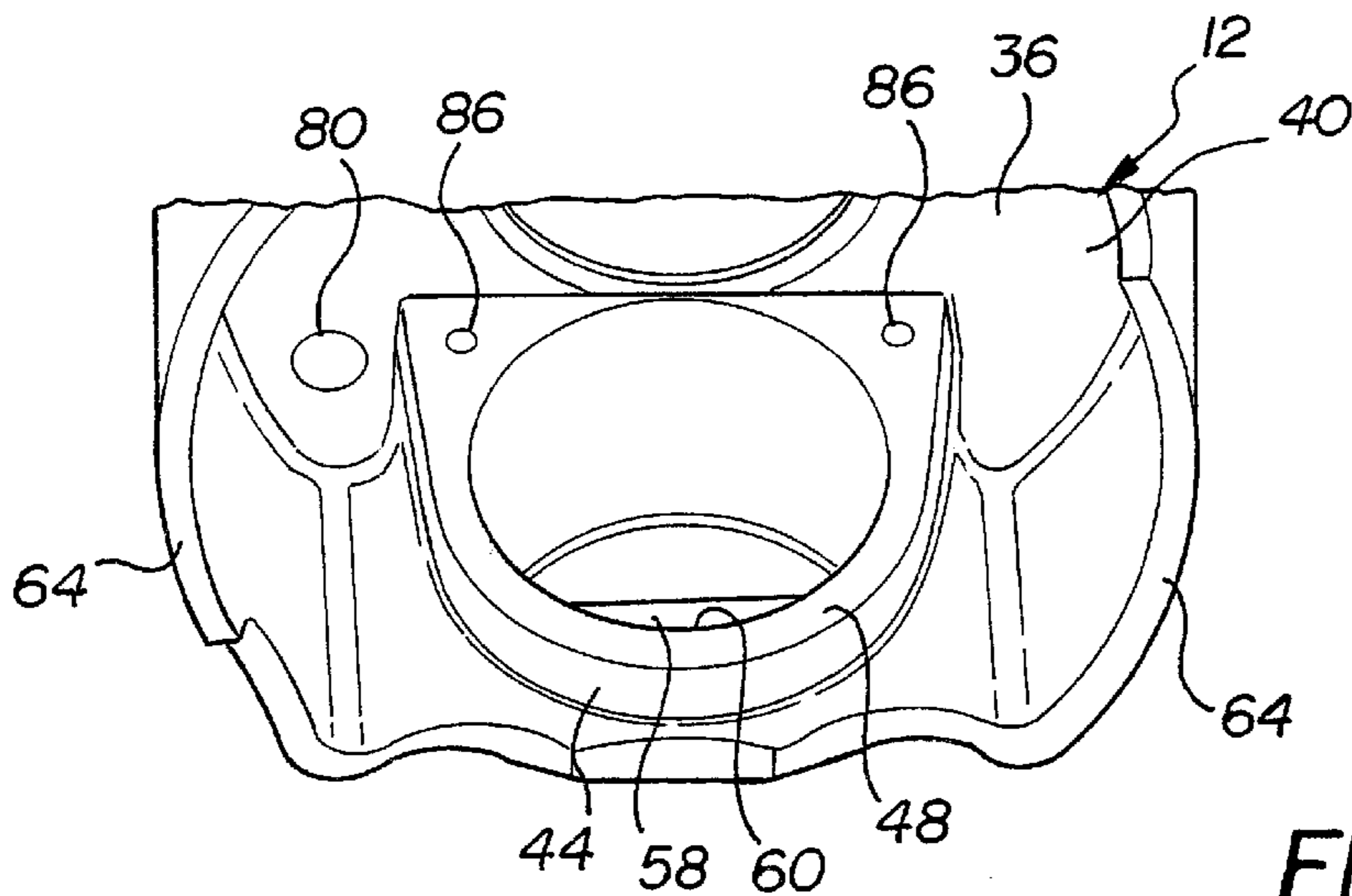


FIG-5

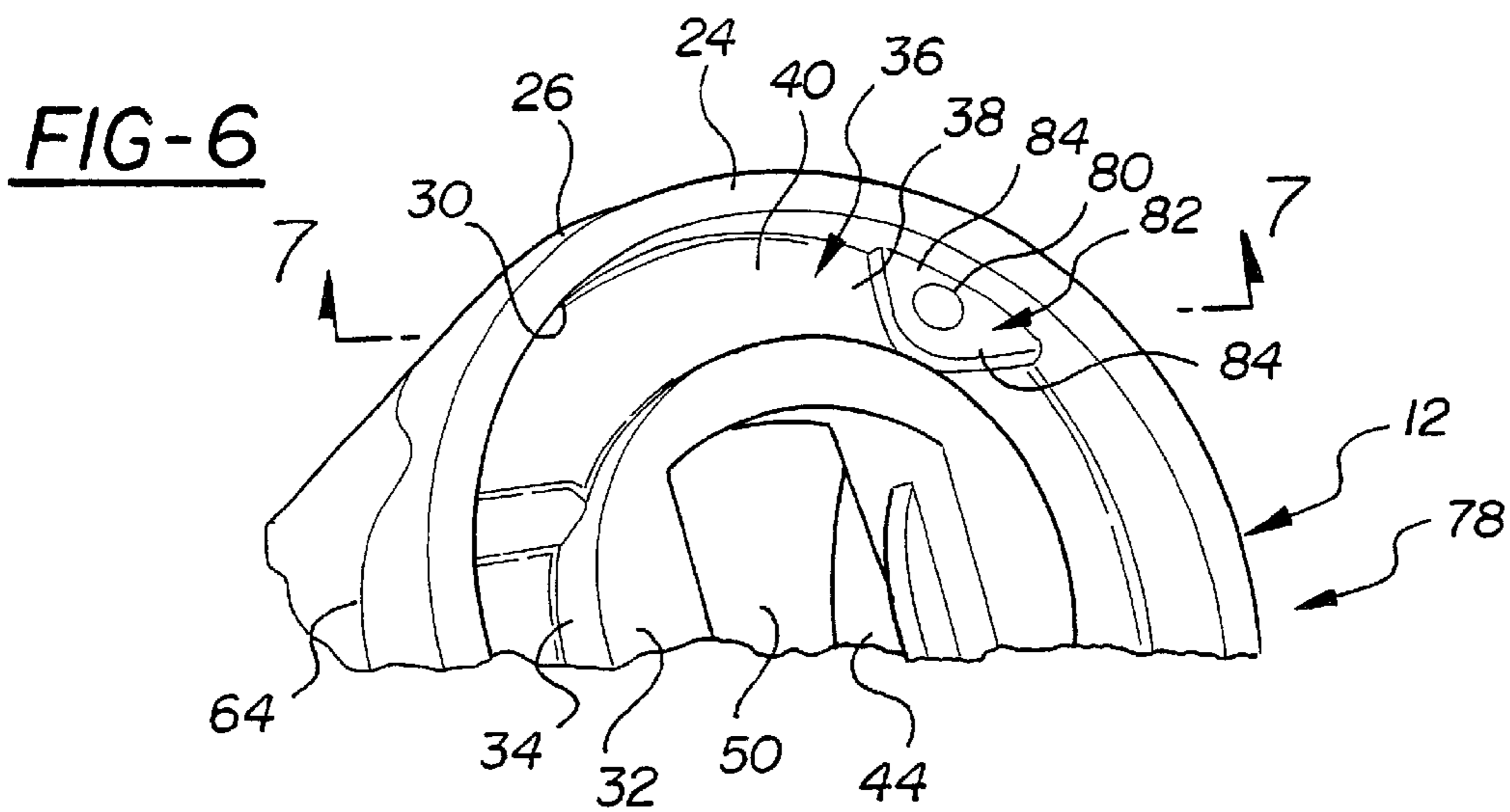


FIG-6

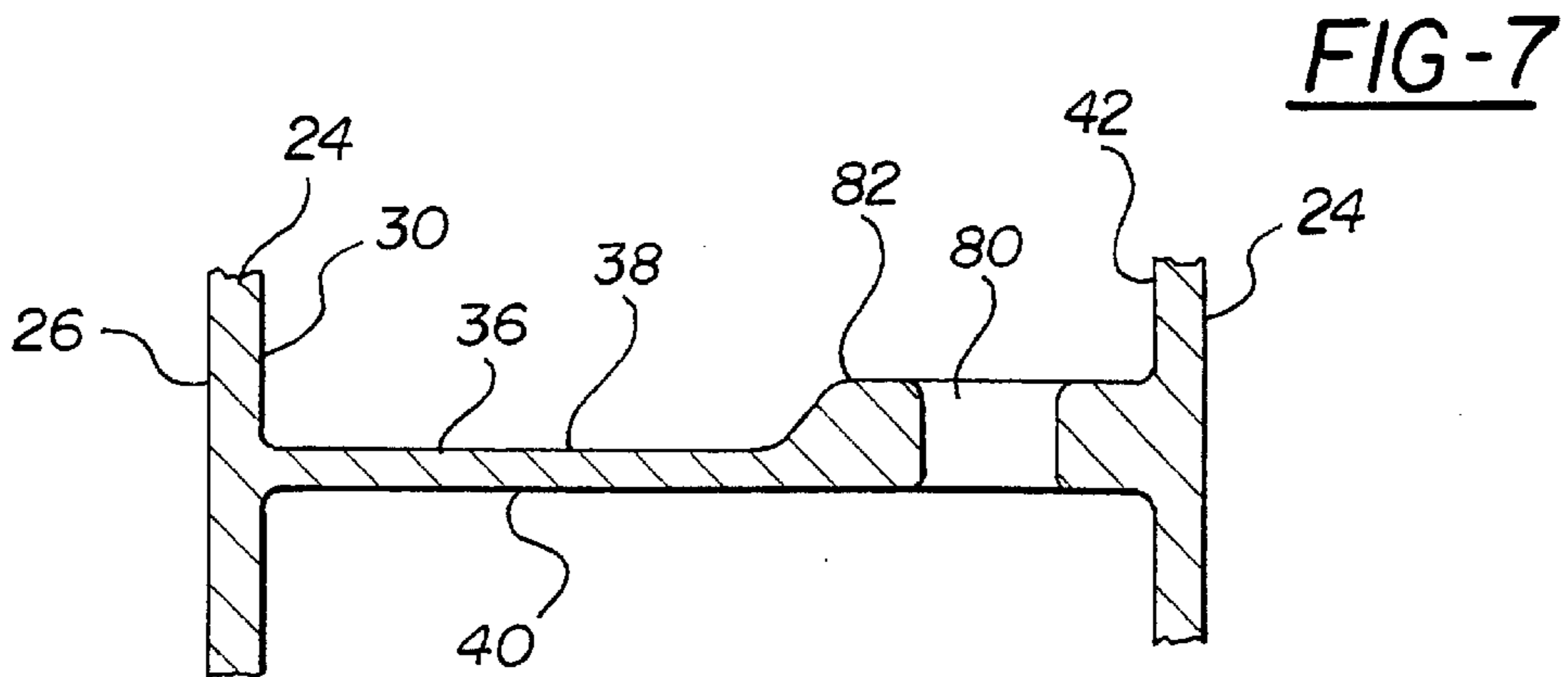


FIG-7

CLOSED GALLERY PISTON HAVING CON ROD LUBRICATION

BACKGROUND OF THE INVENTION

1. Technical Field

This invention relates generally to pistons for diesel engine applications, and more particularly to those having a closed gallery in the piston body for cooling and lubrication.

2. Related Art

It is common in diesel engine applications to provide a piston having a piston body formed with a closed gallery for cooling oil. The gallery typically is formed just inside the ring belt and beneath the combustion bowl for cooling the upper region of the piston during operation. Oil which is directed into the gallery for cooling is typically diverted out of the gallery through various passages for further cooling and/or lubrication of other regions of the piston, or simply discharged through passages to the interior cavity of the piston where it drains back into the crank case.

In a typical piston assembly, lubrication passages are directed to the cylindrical pin bore surfaces of the pin bosses for lubricating the wrist pin which connects the piston body to the upper end of a connecting rod. There is no direct lubrication provided to the side faces of the connecting rod and pin bosses.

It is an object of the present invention to improve the lubrication of closed gallery pistons for diesel engine applications.

SUMMARY OF THE INVENTION AND ADVANTAGES

A piston for diesel engines constructed according to a presently preferred embodiment of the invention comprises a piston body having an oil gallery and a pair of pin bosses with aligned pin bores. The pin bosses have axially inwardly directed inner faces which surround the pin bores and are separated from one another by an intervening space between the pin bosses for receiving an upper end of a connecting rod. At least one oil passage extends from the gallery and opens to at least one of the inner faces to provide direct lubrication of cooling oil to such surface.

The invention has the advantage of providing a closed gallery piston with direct lubrication of the inner surfaces of the pin bores which interact with corresponding outer faces of the connecting rod. This ensures that these interface surfaces are directly and properly lubricated.

Another advantage of the present invention is that the direct lubrication of the inner pin boss surfaces can be readily achieved by a few added steps in the manufacturing process so as to enable the manufacturer of pistons to include such lubrication without departing substantially from conventional piston making practice.

The invention has the further advantage of prolonging the operating life of the piston, wrist pin, and connecting rods by servicing them with direct lubrication during operation of the engine.

THE DRAWINGS

These and other features and advantages of the present invention will become more readily appreciated when considered in connection with the following detailed description and appended drawings, wherein:

FIG. 1 is an elevational view of a piston constructed according to a presently preferred embodiment of the invention;

FIG. 2 is a cross-sectional plan view taken along lines 2—2 of FIG. 1;

FIG. 3 is a partially sectioned plan view taken generally along lines 3—3 of FIG. 2, but of the entire piston assembly;

FIG. 4 is a cross-sectional elevation view taken generally along lines 4—4 of FIG. 2, but of the entire piston assembly;

FIG. 5 is a fragmentary bottom perspective view of the piston of FIG. 1;

FIG. 6 is a fragmentary top perspective view, with a top portion of the piston removed, as in FIG. 2; and

FIG. 7 is a fragmentary cross-sectional view taken generally along lines 7—7 of FIG. 6.

DETAILED DESCRIPTION

A closed gallery piston assembly constructed according to a presently preferred embodiment of the invention is indicated generally at 10 in FIG. 1 and comprises a piston body 12 having an annular top wall 14 with an upper surface 16. A combustion crater or bowl 18 extends into the top wall 14 from the upper surface 16. The top wall 14 has a lower or underside surface 22 opposite the upper surface 16.

The piston body 12 has an outer wall or ring belt 24 that is annular and extends downwardly from the top wall 14. The outer wall 24 has an outer annular peripheral surface 26 formed with a plurality of ring grooves 28. The outer wall 24 includes an inner annular surface 30 spaced radially inwardly from the outer surface 26.

The piston body 12 includes an inner wall 32 projecting downwardly from the combustion bowl 18 and having a radially outwardly facing surface 34 spaced radially inwardly from the inner surface 30 of the outer wall 24.

The piston body 12 has an annular bottom wall 36 which is spaced from the top wall 14 and extends between and interconnects the outer wall 24 and inner wall 32 adjacent their lower ends. The bottom wall 36 has an upper floor surface 38 and lower surface 40.

Collectively, the walls 14, 24, 32 and 36 define an interior, annular, ring-like cavity or gallery 42 within the piston body 12 that is closed by the walls. As illustrated in FIGS. 2—4, the gallery 42 extends completely around the piston body 12 and is bounded at the top by the top wall 14, at the bottom by the bottom wall 36, at the outer periphery by the outer wall 24, and at the inner periphery by the inner wall 32. By “closed” it is meant that the gallery 42 is closed at the bottom by a structural component of the piston body 12, namely the bottom wall 36, which not only extends between but joins the lower ends of the outer wall 24 and inner wall 32. As will be explained further below, various openings and passages are provided to allow cooling oil to circulate into and out of the gallery 42, and thus the term “closed” contemplates the provision of such openings and passages to accommodate the flow of cooling oil through the gallery 42. It will also be appreciated by those skilled in the art that the terms “top”, “bottom”, “inner” and “outer” in describing the walls are intended and should be construed to represent portions of the surrounding wall structure which enclose the gallery 42 and should not be strictly construed based on the illustrated embodiment shown in the drawings since the particular shape and size of the gallery 42 will likely change from piston to piston depending on the particular cooling requirements necessary for a particular application.

The piston body 12 is further formed with a pair of pin boss portions 44 that are formed and preferably investment cast as one piece with the inner wall 32 and bottom wall 36 from steel. The pin bosses 44 have outer faces 46 that face

away from one another and inner faces **48** that face toward one another. The inner faces **48** are each generally planar and preferably divergent toward the bottom of the pin bosses **44**, and define a space **50** between the inner faces **48** for accommodating a connecting rod **52** (FIG. 4). A dome or cavity **54** may extend above the space **50**, as shown, for cooling the combustion bowl **18**. The surfaces which form the cavity **54** extend from, but out of the plane of, the inner faces **48** of the pin bosses **44** and, in the illustrated embodiment, are provided in part by inner surfaces **56** of the inner wall **32**. The pin bosses **44** are formed with axially aligned pin bores **58** having pin bore surfaces **60** which are substantially cylindrical and aligned about a pin bore axis A (FIG. 3). The outer and inner faces **46**, **48** surround the pin bores **58**. The pin bores **58** receive a wrist pin (not shown) which serves to interconnect the piston body **12** with the connection rod **52**. The pin bore surfaces **60** provide support to the wrist pin, preferably without the assistance of any bushings, such that the pin bores **58** are preferably bushingless. Each of the pin bores **58** includes an annular snap ring groove **62** for receiving a snap ring to secure the wrist pin (not shown) within the pin bores **58** in usual manner.

The piston body **12** also includes a piston skirt **64**. The piston skirt **64** is preferably cast as a single piece with the pin bosses **44**, thus providing a monobloc piston structure rather than an articulated skirt. The skirt could, however, be formed as a separate structural component from the piston body **12** and joined through the wrist pin (not shown) in articulated manner to the pin bosses **44**, while retaining the closed gallery structure of the piston body **12**, but the monobloc structure is preferred. The piston skirt **64** has an outer surface **66** extending between the pin bosses **44** that is substantially in line and forms an extension of the outer surface **26** of the outer wall **24**. The outer surface **66** is interrupted across the pin bores **58** to provide recessed side faces **68** where the skirt **64** joins the pin bosses **44**. An inner surface **70** of the piston skirt **64** defines a space **72** adjacent the pin bores **58** that is walled off by the skirt **64**.

The closed gallery structure of the piston body **12** is preferably achieved by forming the piston body **12** from at least two separate parts which are subsequently joined across a joint or joints **74** to effectively yield a united, one piece body structure once joined. While there are a number of ways to join such separate components, all of which are contemplated by the invention, the preferred approach is to join the separately formed components across a friction weld joint **74**, as illustrated in FIGS. 3 and 4. In such case, a top part **76** above the joint **74** is separately formed from a bottom part **78** on the opposite side of the joint **74**, and the separately formed parts **76,78** are then friction welded together across the joint **74** to yield the united structure as shown in the drawings. Some examples of other joining techniques that are contemplated include other means of welding, bonding, brazing, screw thread joint, and other mechanical and metallurgical means of uniting the separate components together to yield the closed gallery structure of the piston body **12**.

According to a further preferred aspect of the invention, at least the bottom part **78** is investment cast from steel, and the top part **76** may likewise be investment cast from steel or formed by other techniques such as forging or other casting techniques.

Referring now particularly to FIGS. 2 and 5-7, the bottom wall **36** of the piston body **12** is formed with at least one and preferably two oil access holes **80** which extend from the lower surface **40** of the bottom wall **36** within the space **72** into the oil gallery **42**. The oil holes **80** preferably are entry

ports for introducing cooling oil into the gallery **42**. When the piston **10** is installed in a diesel engine, the oil holes **80** communicate with associated oil injection nozzles (not shown) which direct a stream of cooling oil from below up into the space **72** and into the gallery **42** through the holes **80**. Once in the gallery **42**, the cooling oil serves to cool the upper part of the piston body **12**, extracting heat from the walls as the oil is moved about in the gallery **42** with a "cocktail shaker" action during reciprocation of the piston **10**.

Because of the closed gallery structure of the piston body **12**, the combustion forces exerted on the top wall **14** which drive the piston **10** downwardly in the cylinder are transferred to the pin bosses **44** not only through the inner wall **32**, but also through the outer wall **24** and interconnecting bottom wall **36**. As such, the outer wall **24** and bottom wall **36** serve as structural load-bearing portions of the piston which must withstand the forces of combustion and transfer such loads to the pin bosses **44** without failure. The oil holes **80** and the bottom wall **36** represent an abrupt discontinuity in the bottom wall structure, and thus a potential site for stress concentration and potential failure. The present invention addresses this problem by reinforcing the piston body structure in the vicinity of the oil holes **80** to counteract the stress concentration effects caused by the introduction of the oil holes **80** in the bottom wall **36**. According to the invention, the piston body **12** is formed with oil hole bosses **82** bordering the oil holes **80**, which are best shown in FIGS. 2, 6 and 7. The oil hole bosses **82** are defined by localized thickened portions of the bottom wall **36** which immediately border the oil holes **80** in order to give added structural integrity to the bottom wall **36** in the area surrounding the oil holes **80**. As illustrated most clearly in FIGS. 6 and 7, the oil hole bosses **82** extend above the upper floor surface **38**, such that the thickness of the bottom wall **36** immediately adjacent the oil hole bosses **82** is thinner than that of the portion of the bottom wall **36** making up the oil hole bosses **82**. The oil hole bosses **82** preferably extend into and are formed as one piece with the outer wall **24**, providing added structural integrity to the transition region between the outer wall **24** and bottom wall **36** in the vicinity of the oil holes **80**. It is preferred that all corners of the oil hole bosses **82** are rounded, as illustrated in FIGS. 6 and 7 to reduce stress concentration.

As shown best in FIGS. 2 and 6, the oil hole bosses, when viewed from above in plan, have a non-circular shape and preferably include generally triangular regions or portions **84** where the oil hole bosses **82** join the outer wall **24**. It will be appreciated that the particular size and shape of the oil hole bosses **82** will be governed in large part by the structure needed to counteract the stress concentration imparted by the presence of the oil holes **80**. One advantage of investment casting the bottom part **78** is that the oil hole bosses **82** can be precisely formed to the net or near net shape needed to provide the desired counteracting structure against stress concentration of the holes **80**.

According to another aspect of the invention, at least one and preferably a pair of passages **86** extend from the gallery **42** directly to the inner faces **48** of the pin bosses **44**, so as to provide direct lubrication to the inner faces **48** between the pin bosses **44** and the connection rod **52**. The passages **86** are best shown in FIGS. 4 and 5. In the illustrated embodiment, there are thus four such passages **86**, two servicing each inner face **48** of the pin bosses **44** on opposite side of the pin bore axis A. The passages **86** are spaced from the walls which form the dome **54** and open directly to the inner faces **48** to provide direct lubrication in the gap between the pin bosses **44** and the connecting rod **52**.

5

According to still a further aspect of the invention and as shown best in FIGS. 1 and 3, the pin bores 58 are formed with an axial recess or pocket 88 which extends axially in the direction of the axis A of the pin bores 58 and presents a discontinuity in the cylindrical pin bore surfaces 60. The recesses 88 are preferably concave and are located at least partly above the center line axis A of the pin bores. The recesses 88 extend axially across the full width of the pin bores 58 and thus are co-extensive with the width of the pin bore surfaces 60 between the outer 46 and inner 48 faces of the pin bosses 44. The recesses 88 are aligned axially with one another and are interrupted by the space 50 between the inner faces 48 of the pin bosses 44, as are the pin bore surfaces 60. The recesses 88 are domeshaped or concave in cross-section when viewed in the direction of the pin bore axis A. An oil passages 90 extends from the gallery 42 and opens directly into each of the recesses 88 so as to feed oil to the recesses 88 during operation of the piston 10 across the full width of the pin bores 58. The oil passages 90 preferably originate from the lowest part of the gallery 42 so as to provide a constant supply of oil to the pin bores 58 during the full cycle of movement of the piston. The entry of the oil passage 90 into the recess 88 is preferably about midway between the outer and inner faces 46, 48 of the pin bosses 44 to promote uniform distribution of oil. The recesses 88 serve as reservoirs or holding pockets for oil and continue to feed oil to the pin bore surfaces 60 during the full stroke of the piston 10 to provide full time uniform lubrication.

Obviously, many modifications and variations of the present invention are possible in light of the above teachings. It is, therefore, to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described. The invention is defined by the claims.

6

What is claimed is:

1. A piston for diesel engines, comprising:

a piston body having an oil gallery;

a pair of pin bosses having pin bores aligned about a pin bore axis and axially inwardly directed inner faces surrounding said pin bores and separated from one another by an intervening space between said pin bosses for receiving an upper end of a connecting rod; and

at least one oil passage extending from said oil gallery to an opening in at least one of said inner faces of said pin bosses to provide direct lubrication of cooling oil thereto, said opening of said oil passage being below the bottom surface of said oil gallery at the location of said oil passage.

2. The piston of claim 1 including at least one said oil passage extending from said oil gallery to each of said inner surface of said pin bosses.

3. The piston of claim 1 wherein there are two said oil passages extending from said oil gallery to each of said inner faces of said pin bosses.

4. The piston of claim 3 wherein said oil passages associated with each said inner surface are disposed on opposite sides of said pin bore axis.

5. The piston of claim 1 wherein said inner faces are generally planer.

6. The piston of claim 5 wherein said inner surfaces are non-parallel.

7. The piston of claim 6 wherein said inner surfaces diverge away from said oil gallery.

8. The piston of claim 1 wherein said piston body is fabricated of at least two separate parts which are connected across at least one joint to form said oil gallery.

9. The piston of claim 8 wherein said joint comprises a friction weld joint.

* * * * *